4. ASSESSMENT OF METHODS

4.1 INTRODUCTION

4.1.1 The Ribble ALSF programme has been innovatory in the application of many of the data capture and analytical techniques, in particular the use of LiDAR for the determination of geomorphological form and archaeological monuments, and the use of GIS analytical techniques to establish archaeological potential. It is therefore appropriate to assess the success of these techniques, to determine whether they have potential for future ALSF or similar projects, or to what extent they may need to be adapted in the future.

4.2 ASSESSMENT OF ARCHAEOLOGICAL DATA CAPTURE

4.2.1 ***Assessment of Previous Research and Investigation:*** an assessment of the archaeological sources showed that the Ribble Valley has a substantially intact and visible historic landscape, which has largely survived the ravages of modern development. Also, it is clear that long-term land use patterns have not erased significant extant remains of earlier periods, nor removed the potential for the recovery of buried archaeological deposits. When other significant sites or discoveries (*Section 2.3-7*), such as the Viking hoard from Cuerdale (Graham-Campbell 19992), the Roman fort at Ribchester (Buxton and Howard-Davis 2002), or the prehistoric flint tool assemblage from Marles Wood (Middleton 1993), are taken into consideration, the Ribble Valley's 'known archaeology' provides an indicator of significant potential for new discoveries from many periods.

4.2.2 ***Assessment of Historical Mapping:*** the older historical maps were not found to be of sufficient detail to identify features within the landscape, but were useful to ascertain if any significant changes in the course of the Ribble had occurred since their respective publication. The most useful mapping for the project was without any doubt the OS first edition six-inch maps, which are the oldest standardised source with building and place-names, as well as boundaries and landscape features, and include natural, semi-natural and anthropogenic features; this was published between 1844 and 1852. The scale of the survey was 1:10,560, which, being similar to the modern 1:10,000 mapping, allowed for a rapid and easy comparison between them. Twenty sites were identified from the first edition mapping, which include features such as earthworks, that may be the remains of earlier structures. This prompted the use of LiDAR to investigate such potential features.

4.2.3 The location of historic extraction and industrial sites along the river valley were clearly shown on the earlier OS mapping and as such the source was of particular significance to this project. Essentially, comparisons between the OS first edition map and the modern map defined more succinctly than any other document the twin processes of industrialisation and urbanisation as these transformed the landscape of Lancashire.

4.2.4 As with the current mapping and the aerial photographic sources, the historic-mapping was used to add documentary detail to features that were identified using the LiDAR models. The OS first edition mapping often depicts archaeological monuments, some of which were in use at the time of the survey, and provides names and functions for the features. For instance, areas of palaeochannels coincided with old watercourses shown on the OS first edition mapping, and hachures were often used to depict disused spoil heaps or other substantial earthworks. Comparisons between current mapping and the OS first edition maps provide an indication of how the field systems have changed over the intervening period, and which were the oldest elements.

4.2.5 ***Aerial Photography:*** only five new sites were found using aerial photographic data alone, which is a surprisingly small number, but the aerial photographic mapping did provide full a coverage of the study area, whereas the LiDAR did not. The process of data capture from aerial photographic sources was a lengthy process, requiring the collation of all available photographic holdings in the Lancashire, North Yorkshire and Yorkshire Dales National Park collections. These required scanning (and georeferencing in the case of vertical photography), in order to be viewed easily in conjunction with the current 1:10,000 OS mapping and the GIS datasets.

4.2.6 The modern vertical colour aerial photographic mapping (supplied by Lancashire County Council) was undertaken in 2000 and provided the most recent clear representation of the study area in general. It was useful to provide a general feel for the character of the area, such as patterns of boundaries and networks of roads, and to show the scale of large extraction centres, such as Clitheroe Quarries. The oblique photography, provided by the Lancashire and North Yorkshire HERs, was in black and white, and flown in erratic sorties; as such it did not provide full blanket coverage of the area. However, the full range of vertical and oblique photography from between the end of the Second World War and 2000 highlights the changes in the landscape during this period.

4.2.7 Although only a few of sites were newly identified by this resource, it is perhaps not a reflection of its value, as oblique photography had been previously consulted and most features found had already been accessioned into the HER records.

4.2.8 ***LiDAR***: the LiDAR data proved to be invaluable for the determination of palaeochannels, which can be seen to riddle much of the area (particularly in North Yorkshire), and was effective at locating and recording all forms of potential archaeological feature. It explained the presence of landscape features encountered during the ground truthing, aided the targeting of palaeobotanical work, and avoided the need for trenching to confirm if a feature was anthropogenic in origin.

4.2.9 The landscape scale of the project demonstrated the potential use of LiDAR for both tracing and accurately measuring long linear features. This was highlighted at Ribchester, which lies at the junction of a series of Roman roads. In places the roads were known from excavation, in others they were marked as projected and were no longer seen in the landscape as a current road or hedgeline. The approach to Ribchester from the east shows such a projected line of a Roman road, and the HER has created a GIS record for this road based on the OS projections. When the entire available LiDAR raster was examined, the lines of these features were clearly defined. (Fig 54). The LiDAR hillshade function (*Section 3.9.14*) was used to show low to high height values as dark to light, and the road showed as a low bank running across the field, deviating from the OS projected line by as much as 90m to the south. The LiDAR slope models (*Section 3.9.17*) were also compared to areas of known archaeology to confirm that archaeological features were definitely being enhanced by the modelling technique. A slope model was created of the earthworks surrounding Sawley Abbey, and then further used to enhance the current vertical colour aerial photographs (Fig 55). The advantage of a slope model over a hillshade model is that no part of the landscape is left unilluminated, and that the new raster is not a product of shadow but is an actual representation of the ground and therefore can be measured. In this way the actual distance, for example between the crowns of ridge and furrow, can be measured, and allows a better determination of the form of such landscape features.

4.2.10 The most striking method of interrogating the data was to use ArcScene to examine the landscape models in close detail. ArcScene allows the user to attribute height values to the slope models in three dimensions and the ability to control the azimuth (that is the angle in degrees from north) and the Illumination altitude of the light source, in this case the hypothetical position of the sun. This creates a user-controlled oblique view that can then be panned and zoomed to identify sites. This added detail was compared to sites that had been previously accessioned into the archaeological record as cropmarks to assess LiDAR's ability to pick up and refine subtle surface features. At Rathmell in North Yorkshire, for instance, aerial photographs have revealed areas of surviving ridge and furrow, but the LiDAR was able to enhance this area and bring out substantially more detail (Fig 56). Similarly, photographs of reclaimed marsh west of Preston Docks, around Longton, had previously identified areas interpreted as 'Vague sub-Rectangular Cropmarks' (HER PRN3146), but the LiDAR shows the area to comprise palaeochannels and flood defences (Fig 57).

4.2.11 LiDAR has proved to be an exceptionally useful resource, providing the main source material for the majority of the new sites identified during the project. The total number of new sites identified within the Lancashire study area was 189; of these, 162 were identified either directly from LiDAR slope or shade models or from enhancement of other sources by LiDAR.

4.2.12 The use of LiDAR for the project has clearly demonstrated the potential for this type of remote sensing to inform archaeological research, particularly at a landscape scale. The integration of data of this nature is at present comparatively rare in commercial archaeology, given the cost implications. From the results of this project, it is strongly recommended that where possible LiDAR be utilised as it provides a valuable landscape assessment resource.

4.2.13 ***Assessment of Secondary Sources:*** a literature search (*Section 3.9.19*) was used to create an overall picture of the Ribble Valley study area, the starting point being the investigation of the current landscape. As such, this borrowed from the Characterisation approach. The Countryside Character Areas (Countryside Commission 1998) and their accompanying landscape description reports, as well as GIS datasets from English Nature outlining SSSI, Conservation and Designated Ancient Woodland areas, were effective in defining the character of the landscape.

4.2.14 ***Archaeological interventions, excavations and surveys (Grey Literature):*** this information was used to enhance the known information held within the HER regarding events within the wider region as well as the study area, in order to provide a clear understanding of the circumstances under which archaeological sites have been revealed. The main contribution of this work was to provide an assessment of the known archaeological works, interventions and surveys that have been carried out in the study area, and to show how the known archaeological resource has been discovered. This work has also contributed to the assessment of areas of disturbance, for example the records regarding the construction of Preston Docks (Dickinson 1887), areas of intensive quarrying and other extractive industries, and reports from excavations in advance of urban development in recent years.

4.2.15 The largest single body of sites recorded by any event record was generated by the *Ribble Valley Survey of 1890s mapping* carried out by Lancaster County Archaeological Services (Lancashire HER 2006), which generated a large volume of sites, including 155 which fell within the study area. These mainly relate to standing buildings, and other extant features associated with post-medieval development, though the farmhouses and barns may have earlier predecessors. It clearly demonstrates the capability to produce detailed site records from high-quality map sources.

4.2.16 A second substantial survey was the *Ribble Valley Catchment Archaeological Rapid Identification Survey* (LUAU 1997b). This was carried out between January and March 1997 on behalf of the Environment Agency, and was designed to enhance the management of the archaeological resource, in the event of river management works. From the results of this survey, 149 sites were recorded, of which 77 were previously in the HER, and these were revisited in order to assess their condition. The remaining 72 sites were discovered as a result of the survey itself, but had not been added to the HER as yet. This provided a valuable source for post-medieval, mainly industrial, sites but was within a very narrow corridor centred on the line of the Ribble.

4.2.17 The *Ribble Valley Catchment Archaeological Rapid Identification Survey* showed how valuable visual assessment can be in recording the character and remains of areas of archaeological resource. Between the two surveys, some 304 sites were recorded in the study area alone. The use of such bodies of data for assessment is crucial to an understanding of the wider landscape, in contrast to the more localised micro-perspective of most excavations. Additionally, the general background history to both the wider region and the valley itself was substantially informed by the collation and synthesis of the previous research and results of excavations and surveys carried out over the last three decades across the north-west of England (*Section 3.9.4*).

4.2.18 As well as the search, a more general search of secondary sources was undertaken, which provided a wide historic and archaeological background for the project (*Section 3.9.19*). This involved visiting Local Libraries and Record Offices in Preston, Clitheroe, Northallerton, and Lancaster. Despite the extensive nature of the research, it was found that individual records in general volumes were typically those that were well documented within the HER and grey literature, as the same sources had been accessed to inform the HER.

4.2.19 ***Assessment of Ground Truthing:*** initially, two areas were chosen for this exercise, firstly an area around Osbaldeston Hall (Fig 58), immediately south of Ribchester (SD 6438 3441). The second area was a corridor running north from the village of Rathmell (SD 80423 59957) to the junction with the A65, south of Giggleswick station (SD 8067 6244; Fig 58).

4.2.20 The area round Osbaldeston Hall Farm was chosen because it was one of the locations selected by the University of Liverpool for geological drilling and could therefore link in to the geological analysis. It also had a varied topography and land use and had previously recorded monuments from the HER: Osbaldeston Hall Farm (HER PRN1815), Osbaldeston Sheepfold (HER PRN28248), Osbaldeston Clay Pit (HER PRN21619), Osbaldeston limekiln (HER PRN28249) and Dobridding Stepping Stones (HER PRN28247). The area had yielded new sites from LiDAR comprising a series of long, wide and low features (Fig 59) located on the low-lying river terrace.

4.2.21 The current land owner had no knowledge of there being any drainage or flood alleviation works being undertaken during his time there (C Bargh *pers comm*), nor was there any photographic or HER information for the immediate area. The field inspection confirmed the existence of the long linear banks, though in places these were so subtle as to be barely perceptible from ground observation, but they were ultimately interpreted as a series of palaeochannels.

4.2.22 The ground truthing demonstrated that a sheepfold (HER PRN28248), located to the west of Osbaldeston Hall Farm and close to the river bank, and a series of stepping stones (HER PRN28247), were no longer extant. New discoveries included a disused engine mounted on sandstone blocks with a brick-built foundation, located in Old Park Wood east of Oxendale Hall (SD 65406 33551), and also a field of regular, well-defined ridge and furrow west of Oxendale Hall (SD 64895 33344) in an area that did not have LiDAR coverage.

4.2.23 ***Conclusion:*** the collation of the known archaeological research and investigations was most effective for understanding the character of the archaeological resource within the study area and its wider context. It allowed an understanding of the previous settlement and land use patterns, by allowing the display of data as points, polylines or polygons within the GIS, and thus spatial patterns to be identified.

4.2.24 The data from the HLC provided a basic entry level of historic information and divided the area into parcels of HLC types which could be used in comparison with the distribution monument and event data. As the HLC was GIS based, it was possible to extract the records for the area and then add in an almost limitless number of additional fields to carry more information about each delineated area. The most useful for assessing potential and threat were the fields which had archaeological density data added to them. The HLC data were also used to capture the monument and event data within each polygon, which formed the basis of the HLC gazetteer records.

4.2.25 The only limitation of HLC data use was as a statistical test, since the nature of the primary data was too subjective and did not really represent the same kind of continuous data as a geological or topographical dataset. This was the reason for the abandonment of the Lynher Valley method, as the results were not suitable for the KS test.

4.2.26 The most useful historic mapping was undoubtedly the OS first edition six-inch mapping. This defined the area at a time of great change, developing industries and the increasing adoption of mechanised agricultural techniques, which created different patterns of land use. The associated growth of towns and the large-scale building of workers' housing encroached on the surrounding countryside. By direct comparison with the historic and current maps, it was possible quickly to see where areas have undergone higher or lower levels of change in character during the intervening period.

4.2.27 The aerial photography (both low-level oblique and vertical) has been of great help to the project, providing a visual element to the desk-based assessment, although it has been overshadowed by the LiDAR data. In conjunction with the LiDAR, however, it has allowed the detailed mapping of the landscape and the identification of many new potential archaeological sites. The ability to manipulate the LiDAR data to create different views and the ability to measure features from the images has increased the pace and detail with which new sites are discovered.

4.2.28 By taking all these sources together to investigate the landscape, a clear picture of the known resource can be identified, and from this the unknown can be predicted, and specifically predictions can be made for an archaeological resource in areas where there have been no archaeological events recorded. The use of ground truthing has been important to check that the data identified on maps, photographs and LiDAR were actual and that the interpretation was correct.

4.2.29 Visual assessment could also be used in areas in which LiDAR was ineffective, such as woodland floors, and most obviously in the gaps in the LiDAR coverage. An essential part of ground truthing is the ability to familiarise the landscape archaeologist with the study area and to get a 'feel' for the landscape, which cannot be fully achieved through mapping and photography alone.

4.2.30 One omission in the datasets is the difference between the records that exist in the Portable Antiquities Scheme (PAS) database, and those that are held by the Lancashire HER. The data received from the PAS contained 124 records in and around the study area, and the PAS contains 58 records that were recorded as being in or around Clitheroe alone. The results of this survey or any work based on the distribution of archaeological material would be altered greatly by the inclusion of the entire PAS dataset (Table 20).

Area	**Period**	**Count of PAS records (Oct 2006)**
Clitheroe	Bronze Age	1
Clitheroe	Early medieval	1
Clitheroe	Iron Age	4
Clitheroe	Medieval	31
Clitheroe	Post-medieval	10
Clitheroe	Roman	11
Preston	Bronze Age	2
Preston	Medieval	3
Preston	Post-medieval	11
Preston	Roman	16
Ribble Valley Area	Iron Age	1
Ribble Valley Area	Medieval	1
Ribble Valley Area	Post-medieval	3
Ribble Valley Area	Roman	1
Ribchester	Medieval	2

Area	Period	Count of PAS records (Oct 2006)
Ribchester	Post-medieval	3
Ribchester	Roman	3
Ribchester	Unknown	1
Whalley	Medieval	3
Whalley	Post-medieval	15
Whalley	Roman	1

Table 20: Summary table of PAS records within the Lower Ribble Valley study area

4.3 Assessment of Statistical Methods

4.3.1 Various methodologies were applied in the enhancement of the HLC and the modelling of archaeological potential (*Section 3.13*). Unlike in the earlier stages of the project, it was not possible to assess these methodologies on the basis of new sites being created, and from the outset the statistical techniques applied were those considered most appropriate for the types of data being analysed. Furthermore, some compromises must be made when attempting to use any kind of statistical techniques on this type of data.

4.3.2 ***The Lynher Valley Approach***: this methodology produced very little in the way of usable data. The approach for calculating the relative significance of monuments within HLC polygons was slightly flawed statistically, as it compared a value that represents the percentage of an area (the HLC polygons), with a value that represents the percentage of a total (the number of monuments). By changing this approach to use the KS test, it was possible to conduct very similar analyses in a statistically valid way by comparing two sets of area percentages, giving a true indicator of correlation.

4.3.3 ***The KS Test Approach***: using the KS test on monuments represented by point data was an improvement on the Lynher Valley approach; however, it had its own limitations. Polygonal extents for all the monuments within the study area were unfortunately not available, and it was therefore decided to use point locations for consistency, which is a tried and tested approach (Ebert and Singer 2004; Wheatley 1995). There was, however, a question as to whether a single cell can truly represent the location of extent of a Roman fort or a single findspot. In this case, a 10 x10 m cell size was carefully chosen as a trade-off between file size and aggregation of closely located sites, and to provide an improved indication of the environmental parameters at a particular location.

4.3.4 This point-based approach was particularly unsuitable for linear monuments because a centroid point would be an inadequate representation of the location of the feature, and also because long linear monuments may well traverse several different elevations/slopes. It was therefore concluded that cell-based modelling was appropriate for certain types of analysis, but not in areas where many long linear monuments might be located.

4.3.5 Historically, this type of 'predictive modelling' has been criticised, on the grounds that the model can only be as good as the data from which it is created (Chapman 2006, 158). Also, it represents a departure from traditional methods of researching site location, abandoning ideas of settlement and subsistence in favour of land parcels (cells) and environmental parameters favouring site location (Warren 1990, 94). Ultimately, it will only be judged a success if a new site is discovered as a result of the model, yet from a cultural resource management perspective, the aim should be to avoid areas of high cost and time in terms of archaeological mitigation. Consequently, a new approach tends to be adopted, known as the ‘Red Flag Model’, that highlights regions of predicted high archaeological potential as areas for developers to avoid (Altschul 1990, 227).

4.3.6 From the point of view of the present project, this new model works well. It provides a method for highlighting areas (of archaeological potential) to be avoided by developers within the study area, and should be a valuable management tool in the future.

4.3.7 When applied to monuments classified by NMR Broad Types, the KS test approach failed to produce positive results. In the case of the HLC broad types, there was little correlation between HLC broad type for polygons within the study area, and the NMR Broad Type of the monuments. Similarly, there was little correlation between monuments classified by NMR Broad Type, regardless of period, and environmental parameters. The results may be valid, and may indicate that the monuments were equally spread where their Broad Type is concerned, but this may also be a symptom of the large number of NMR Broad Types and the commensurately small number of monuments of each type.

4.3.8 When applied to monuments classified by period, the results were more usable, in the sense that some clustering was evident. This classification also makes more sense from a management perspective, as it is conceivable that differing importance would be placed on monuments of different periods rather than different types.

4.4 ASSESSMENT OF GEOLOGICAL AND GEOMORPHIC TECHNIQUES

4.4.1 The principal outcomes in terms of technique development and refinement of these studies are that geomorphological mapping, with the assistance of remotely sensed DEMs, is an essential precursor to fieldwork where appropriate data are available, because of the tremendous benefits for mapping accuracy, cost-effectiveness and speed. Nevertheless, fieldwork was still clearly essential to assess the composition of identified features, for corroboration, and to assess the relationship between critical features, for example altitudinal, cut and fill, and sequence relationships. Of the available digital products, LiDAR is currently the best and it is possible to be interrogated to discern low amplitude differences between terrace features, for example the Holocene river terracing of the Lower Ribble and palaeochannel expression and morphology on the surface of river terraces. NextMAP data perform almost as well in this regard, but it was more difficult to discern features of reduced extent and amplitude in this, for example small-scale scroll-bar palaeochannels. Both datasets have limitations, particularly adjacent to standing buildings or features, and in dense woodland. OS Profile data were also capable of depicting landform geometry to a relatively high standard, but struggle as the size of the target features was reduced. The limitations of use for all these datasets reflect their specifications in terms of spatial and vertical resolution.

4.4.2 The approach adopted with this project involved computer-based mapping, using existing data sources (geological maps and georeferenced academic research), coupled with detailed interrogation of DEMs to map the landscape morphology. This initial stage was the precursor to field assessment, a process rendered more spatially precise and rapid by the computer-based assessment. The interpretations of the DEMs enable rapid identification and location of appropriate sites for the drilling programme. This stage of research is therefore a valuable and arguably essential precursor to accurate geomorphological investigation.

4.5 TOWARDS A REFINED METHODOLOGY FOR AGGREGATE RESEARCH

4.5.1 The geomorphological survey approaches advocated in *Section 4.4* are the first stage of aggregate assessment. Producing an accurate geomorphic assessment and discerning sediment-landform assemblage relationships, and then producing palaeogeographic models, allows prediction of the sedimentary composition and hence its potential as an aggregate resource. The rapidity of the computer-based geomorphological assessment means that, with geomorphological 'expert' knowledge, it is possible to assess new areas, providing links can be made with archived borehole and/or section evidence. With geomorphological expertise, aggregate surveys can cover larger areas, reducing the need for sand and gravel surveys with a restricted spatial brief (eg Entec UK Ltd 2005; and to a lesser extent Geoplan 2006). In the long-run, however, it is crucial that geomorphological and sedimentological interpretation is supported by field evidence. However, the mapping process allows refinement of the field mapping and borehole programmes to target critical locations (Crimes *et al* 1992; 1994), thereby significantly reducing the quantity of boreholes needed and reducing the cost of aggregate survey.

4.5.2 DEMs and the use of GIS software are invaluable in accurately gauging the volume of sand and gravel prospects, because cut/fill equations within raster analysis software can calculate the volumetric residual between two elevation surfaces, the first of which is the ground surface and the second an estimation of the base of the deposit. The quality of these predictions is only as good as the data on which they are based, and so access to borehole evidence, section exposure and the production of accurate sediment/landform and palaeographical models is crucial.

4.5.3 Prior to any extraction, further data will be needed to identify hydrogeological problems, clarify and quantify the nature and quality of the deposit (drilling of boreholes, excavation of test-pits, sampling of materials and grain-size analysis) (Crimes *et al* 1994). Nevertheless, the methodological improvements advocated for this first stage will improve the accuracy, cost-effectiveness and value of geomorphology-based mineral assessment for the sand and gravel aggregate industry.

